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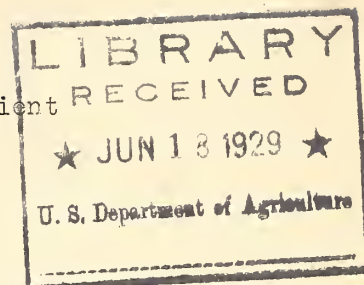
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Weather Service Essential for Safe and Efficient
Operation of Airports.

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weather

The relation between service and airports is twofold. First, there is the statistical phase in which the records for a period of years are analyzed with a view to determining the most suitable location for an airport, the best layout of runways and the proper orientation of hangars. Decision regarding these matters depends, or should depend so far as practicable, upon the relative frequency of such climatic factors as fog and other causes of poor visibility, winds from different directions, and gustiness as influenced by topography and proximity to high buildings and other obstructions. As a rule there is already sufficient information available, in the local records, for reaching a satisfactory conclusion with respect to these factors and their bearing on the selection of the best possible sites for airports. In some cases, however, it has been found necessary to supplement existing data with an intensive survey of local conditions. Such a survey was carried out at San Francisco and one is now in progress at Washington.

But, in the present discussion we are assuming that this phase has been completed, that the airport has been selected, graded, drained, equipped with hangars, and other necessary buildings, and is on an operating basis. We come then to the second phase of the relation between weather service and airports, namely, that concerned with up-to-the-minute reports and short-range forecasts. Let us consider what this service should comprehend, how complete it should be and how large an area outside of the airport should be included.

So far as this discussion is concerned, airports may be regarded as falling into two classes; 1st, those so located that they form an integral and essential part of the service that the Weather Bureau is organizing for airways; 2nd, those that are not so located, but from and to which nevertheless there is a considerable amount of flying, necessitating therefore the provision of service to take care of local needs.

Service at Weather Bureau Airport Stations.

For satisfactory service at Weather Bureau airport stations on established airways there are four principal requirements, namely:

1. Suitable office quarters.
2. Competent personnel.

3. Adequate instrumental equipment.

4. Prompt and dependable communications arrangements.

1. Quarters. Naturally, before any service at all satisfactory can be given, a place to work in must be provided. The experience of the past two years indicates that a space of not less than 400 square feet, preferably 800 to 1000, is needed for properly carrying on an airways weather service. In most cases the Weather Bureau already maintains in the cities themselves a first order station which provides service for other than airways needs. There are a few exceptions such as that at Greensboro, N.C., which had no weather service prior to that organized at the airport. As an experiment that station has been made to include all types of service and therefore a much larger space was provided. However, for our present purposes we do not need to consider these few special cases, but can devote our attention to the needs for airways service alone. It will probably be found that an airways station at the airport, independent from the city office that serves the general public, although cooperating closely with it, is the best arrangement in most cases.

The space provided for the weather service should be divided into two rooms, the smaller to contain approximately 150 to 200 square feet. This is the administrative office. The larger room is the place where the actual service is rendered. Here the reports are received and posted; here the weather maps are made; and it is this place to which the pilot comes to get his bulletins and, when the outlook is uncertain, to talk the situation over with the meteorologist.

These two rooms should of course adjoin. They should be convenient of access to the pilots and operations managers of all the air transport companies regularly using the airport. They should be either in the central administration building or in a separate small building nearby. In general it is believed that the former arrangement is the more satisfactory, but additional experience is necessary before a definite conclusion on this point can be reached.

In cities that already have a first order Weather Bureau station and in which there is need for an auxiliary station at the airport for airways service it is held by the Bureau that the Government should not be expected to assume the cost for these additional quarters. On the other hand, it is believed that the free use of these quarters constitutes a very proper share of the city's cooperation in providing the service. True it is that this service is not primarily for the benefit of the airport or the city, but rather forms a link in the chain of aids for the entire airways system. Nevertheless the airport's importance and prestige are greatly increased thereby, and this fact, if no other, justifies the city in making a definite though

comparatively small contribution, and this can be done most easily and effectively by providing the necessary quarters. It should be stated, and it is a pleasure to do so, that almost without exception the cities have not only willingly but enthusiastically agreed to this plan and have carried out their share in an entirely satisfactory way.

2. Personnel. With quarters provided, the next requirement is personnel. Our conception of what constitutes adequate service has undergone a tremendous change in the course of so short a time as the three years that have passed since the Air Commerce Act became a law. Let us not look to the past except for the lessons that it gives. Let us rather turn our gaze to the future and fashion the service of the present on what we see there.

The airports that we are now considering must function without a pause. Weather service therefore must be organized and maintained on a 24-hour basis. Competent personnel must be selected or developed to provide that service. This is a responsibility that the Weather Bureau, and the Weather Bureau alone, must assume.

Thus far the practice has been followed of selecting and assigning to airport stations some of the more promising young men of the Bureau. Many of these have met the test and are furnishing excellent service. But the demands are increasing all out of proportion to the supply. Moreover, in this field, unlike most others, there is no outside source on which to draw for new material. In commercial life there has, until recently, been no great need for the meteorologist. Happily there are signs that this condition of things is changing. Every great demand creates its own supply, and already some of the colleges are organizing and conducting courses in meteorology which will within a comparatively short time turn out the type of trained men needed for this new service. And, as its part in the program, the Weather Bureau is planning to take in these men and supplement their educational training with actual experience in subordinate positions before assigning them to positions of leadership.

In the meantime its own men who have grown up in the service and who are demonstrating exceptional ability in this line are being assigned to the most responsible positions. Others, less experienced but showing promise of development, are being placed under these leaders for training. At airport stations having 24-hour service there are required at least four men, preferably five or six, the last number, six, being necessary at the major control centers. At stations where night flying is only occasional, a smaller number of men may suffice for a time, but in no case should there be less than two. So far as practicable, a leader is always selected who can not only do the mechanical work of making observations and posting reports but also interpret the data, or, in other words, give the pilots what they most need,

namely, short period forecasts. Eventually, and as rapidly as possible, each airport station will have at least three such men, so that there shall be one on duty at all times throughout the day and night.

3. Instrumental equipment. Having selected the personnel and provided suitable quarters, we come next to the question of proper tools to work with. We can pass without comment the needs for office furniture and take up at once the consideration of what should be included in the way of instrumental equipment. Again we have the benefit of the experience of three years of service for commercial flying, supplemented by that of five or more years of service for the activities of the Government in the Air Mail and Military flying. That experience has provided us with a very definite picture of the weather elements a knowledge of which is of most vital concern to pilots. Those elements are:

- a. General condition of sky and weather.
- b. Ceiling.
- c. Visibility.
- d. Wind direction and velocity.
- e. Temperature.
- f. Dew point.
- g. Barometric pressure.
- h. Miscellaneous, such as thunderstorms, squalls, condition of field as affected by rain, snow, etc.
- i. Upper winds.

For the general condition of sky and weather no instruments are required, but certain definite terms have become standard for expressing it, such as "clear", "broken clouds", "overcast", "fog", "heavy rain", "sleet", etc., etc. This first word in the report tells the pilot at once whether the conditions are satisfactory, impossible or simply uncertain and therefore subject to further study.

The next two items, ceiling and visibility, usually answer this question of uncertainty. For observations of ceiling at night the so-called ceiling light is in general use. Although it serves a meteorological purpose, it forms a part of the lighting equipment developed by the Airways Division of the Department of Commerce and is described in another paper, by an official of that Department. Suffice it here to say that its use makes possible the determination of ceiling quite accurately up to 1000 feet and fairly accurately up to 2000 feet.

For observations of ceiling in the daytime it has been general practice thus far to make an estimate based upon the appearance of the clouds and the known height characteristics of different types. This method is admittedly crude, although fortunately it is most nearly accurate when the information is most needed, that is, when the clouds are low. At airport stations where pilot balloons are used, the ceiling

can be determined with them, but their frequent use is expensive. It is gratifying to be able to state that within the last month or so tests with very small toy balloons have demonstrated that their rate of ascent for the same free lift is very uniform. Action has therefore been taken to supply the airport stations with these balloons. A watch, preferably a stop watch, and a tank of hydrogen complete the outfit. The entire observation can be made in five or six minutes, assuming that the ceiling is not above 2000 feet. When it is higher than that, the information is not very essential, except occasionally in mountain sections.

Observations of visibility are non-instrumental. It is customary to give the greatest distance at which conspicuous objects can be clearly seen. Lights are used at night. This method is approximate only, although, as in the case of ceiling, it is most nearly accurate when the information is of most moment. Some attempts have been made to devise a visibility meter, but thus far none of these has met with success.

It is to be noted that observations of visibility show conditions in the horizontal, not in the vertical. No attempt is made to measure the latter, although it is given indirectly in the report of ceiling.

Wind direction and velocity, temperature, dew point and barometric pressure are all observed by means of well known instruments which need no description. In cities already having a Weather Bureau Office down town the equipment at the airport station is usually less elaborate. For example, there is little need for complete automatic records, since these serve statistical purposes mainly and are provided by the city office. As a rule, therefore, the instruments at the airport are of the indicating type and require little attention, at the same time giving very accurate information. Exceptions are the barograph and hygrograph which provide continuous records of air pressure and humidity, respectively.

Miscellaneous phenomena are observed directly, without instruments. They include thunderstorms, line squalls, exceptionally heavy rain or snow, ice formation as reported by incoming pilots and any other conditions a knowledge of which is useful and at times vital in determining whether or not flights should be made. The airport station's personnel should pay special attention to this part of the reports.

For measurements of upper wind direction and velocity so-called pilot balloons are in general use at airports. These balloons are about six inches in diameter and are made of pure rubber. Different colors are employed to give the best possible visibility against varying backgrounds of sky and cloud. The balloons, when filled with hydrogen, are about 28 to 30 inches in diameter and ascend at an approximately uniform rate of 600 feet per minute. They are followed with a theodolite, and angular readings are made each minute. By means of slide rule, portable telephone and plotting board, computations are made while the observation

is in progress with the result that the wind conditions at various levels are known in detail within two or three minutes after the balloon disappears. For observations at night a small lantern is suspended a few feet below the balloon.

The one weakness of the balloon method is that its use is limited to the levels beneath the clouds. Kites do not have this handicap and are used by the Weather Bureau at some places, but not at airports because of the hazard that the wire or cable would offer to aircraft. The development of suitable and not too costly methods for upper air observation, including temperature and humidity as well as wind in cloudy weather, constitutes a problem that must be met and solved. The data would be of incalculable value not only in determining wind drift but also in forecasting ice formation and other unfavorable conditions.

Briefly summarizing, the equipment at airport stations should include, as a minimum, the following:

- 1 Anemometer, Robinson 3-cup type, with 1/60th mile and 1 mile contacts.
- 1 Wind vane.
- 1 Support, 18-foot, for anemometer and wind vane.
- 1 Indicator board, combined wind direction and velocity.
- 2 Thermometers.
- 1 Thermometer shelter.
- 1 Psychrometer.
- 2 Barometers; 1 mercurial and 1 aneroid.
- 1 Barograph.
- 1 Hygrograph.
- 1 Theodolite.
- 1 Portable telephone set.
- 1 Plotting board.

Balloons, hydrogen tanks, and miscellaneous material required for the proper functioning of the instruments and apparatus above listed.

4. Communications. Even with quarters, personnel and equipment satisfactorily provided, the airport station will still be of little service unless it can get the information to distant points and in turn receive reports from those places. A prompt and dependable system of communications is the fourth and final, and in some respects the most important, link in the chain of service at an airport. The development and maintenance of such a system are functions of the Department of Commerce, and the subject will be fully discussed at this meeting by an official of that Department. Assuming that the system has been organized and is operating satisfactorily, let us consider briefly the main features of the weather service that is thus made possible.

At certain intervals the observer makes his instrumental and other observations, enters the data on a standard form and sends brief reports, by means of the communication system provided, to other points on the airway. This same communication system brings to him similar reports from those points and these he posts on a large bulletin which is displayed in a conspicuous place in the office. In the early days of the service a black board was used for this purpose, but experience has shown that large sheets of paper, suitably ruled, are preferable, principally because two or more of them, containing successive reports, give a picture of the changing weather conditions. They are usually kept on file for a month or so and then destroyed.

The same data that are shown on these bulletins are also in some cases entered on smaller forms called "Pilot's Weather Reports", and one of these is given to each pilot before he starts his flight.

The time interval between observations depends upon the volume of traffic. Wherever this is large, it is found that hourly reports from points along the airways, supplemented by less frequent reports from places some distance therefrom, are needed to provide the best possible service. At places where only a few flights are made daily, reports are furnished to suit the schedules. The former arrangement is being extended as the need develops and will eventually be in effect on all of the lighted airways.

In addition to the frequent reports that constitute the intensive service, the airport stations receive by telegraph the country-wide, twice-daily network of weather reports and these are charted on the well-known daily weather maps which are available for inspection and study by meteorologist and pilot alike. These include the upper wind reports which are entered on special charts. Finally, from the District Forecast Centers come the general weather forecasts and the special airways forecasts. The meteorologist makes use of all these reports and forecasts and at stated intervals along some of the more active airways he combines them in summarized statements and short period forecasts which are broadcast to planes in flight.

It can readily be seen that the communications system forms the keystone of the structure of weather service at airports. It matters not what the system is so long as it is prompt and dependable. Without these qualities the entire system breaks down completely. Delay is fatal, - more so in flying than perhaps in any other line of human activity.

In brief review we may repeat that the essential requirements for the service we are discussing are suitable quarters for proper working conditions; competent personnel for organizing and conducting the service; instrumental equipment to insure accurate reports; and a communications system that will get those reports to their destination

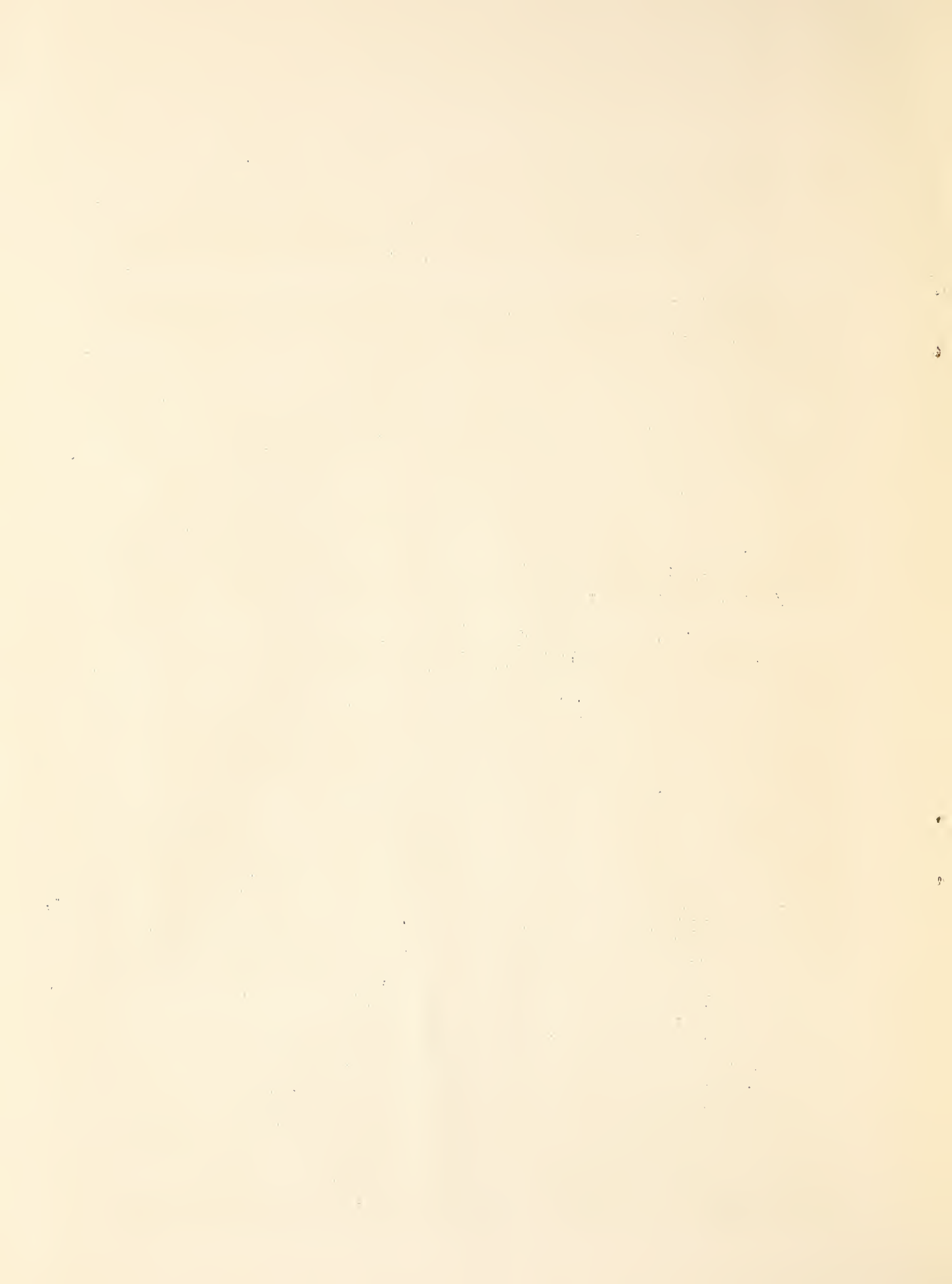
with the least possible loss of time.

Service at Airports that are not Essential as Collecting
and Distributing Centers in the Weather Bureau's System.

We come now to the consideration of airports at which the Weather Bureau requires no special service, other than actual observations, for the development of its system of reports and forecasts for all of the commercial airways in this country. At the outset it is proper to state that, by the terms of the Air Commerce Act, the Government is authorized to provide aids to civil airways except airports. This is interpreted to mean that municipal and private airports must furnish their own equipment, including lights and weather instruments. This interpretation is not in conflict with what has been said in the first part of this paper. It is true that at some of the major airports on established airways the Weather Bureau supplies its own equipment, but it should be borne in mind that this equipment serves the airport as such only incidentally. Its chief purpose is to contribute to the service for the airways system as a whole. In such cases, therefore, the Bureau is justified in supplying the equipment in order to have it of standard type and its use and care under the Bureau's control.

The Airport Regulations issued by the Department of Commerce require that any airport in order to receive a Class A, B, C or D rating must be provided with weather instruments including a wind direction indicator, an anemometer, a barometer and a thermometer. There must also be a bulletin board and facilities for giving pilots the most recent information. These are the minimum requirements. Their cost is small, an insignificant part of the total outlay in purchasing and developing an airport. At such airports as can do so, and particularly at the larger airports, it would be well to make the equipment somewhat more complete, approximating if possible that heretofore described as standard for Weather Bureau airport stations. However, it is not believed essential to install a still more elaborate outfit for procuring automatic continuous records, unless trained personnel are employed to take care of them. Instruments of the indicating type are best suited for the service most needed, that is, observations of current conditions, quickly and easily made.

The question of communications is perhaps the most perplexing one for airports that are not on an established airway. The service, in order to be of real value, must include some reports from other points and the cost of transmitting any large number of these amounts to a considerable sum. A partial solution at least is found in the installation of suitable radio receiving apparatus. By this means it is possible to pick up the country wide reports that are regularly broadcast in code twice daily by the Weather Bureau. In addition to these it should be possible to receive at least some of the bulletins that are broadcast by the Department of Commerce from certain control stations on the major airways. This system is at present in



operation only on a portion of the transcontinental airway, but will undoubtedly be greatly extended within the next two or three years. Then too there are the forecasts, including those for flying activities, that are regularly broadcast in all of the larger cities.

These various sources of information should be supplemented by arrangements for receiving reports from selected places, principally those to and from which most flying is done. Such reports can be exchanged by telegraph or telephone, or by teletype if funds are available.

The matter of funds would also largely determine the type of personnel at these airports. For making the observations and for receiving and posting the reports from other places no specially trained personnel is needed. However, at places where a more ambitious program is to be carried out, including the making of weather maps and local flying forecasts and the taking of upper air observations, only experienced and well qualified meteorologists should be employed. In general this would be unnecessary at airports in cities that already have a Weather Bureau station down-town. In such cases arrangements should be made for a copy of the Weather Map to be sent to the airport. All stations of the Bureau have instructions to do this, if requested, and to cooperate in other ways to the fullest possible extent.

So far as quarters are concerned, here again it is largely a matter of what funds are available and how extensive a program is laid out. It is well to bear in mind that many airports that are not now on established airways are almost certain to be on one or more of them later. When they are, weather service may possibly be furnished at those airports by the Government. If quarters are already available, one of the main requirements is met, without the necessity of making alterations in existing buildings or of putting up a new one not originally planned for and therefore out of harmony with the general scheme. Those who are building airports might well consider the advisability of providing such quarters against the day when they may be used for service by the Government. Should that day never come, the money will not have been wasted as the quarters can still be put to some other use.

The Future.

Earlier in this paper it was stated that our conception of what constitutes adequate airways weather service has undergone a very great change during the past three years. It is true that the fundamentals remain essentially the same as then, but the detail and intensiveness of the system as it exists on certain airways and as it is shortly to be extended to others bear little relation to the service with which we started in 1926. Few then would have dared to hope for such a development in so short a time.

So now, let us guard against anything like dogmatic assertion concerning the requirements and possibilities of the future. Who can question that, perhaps within a comparatively short time, apparatus will be devised whereby the pilot will have before him, in panorama, a complete picture of the constantly changing weather conditions along all parts of his route?

And shall we end with this? Certainly not. What more natural than that successful attempts will eventually be made to alter the weather itself, to the extent at least of dispelling the fog and low clouds, causing the troublesome squalls to follow detours remote from the main airways and possibly setting up zones in which only tail winds shall blow!

Fanciful? Possibly. So was flight itself regarded twenty-five and a half years ago.

